

# BOAT AND SHIP DEPICTED IN THE ROCK ART, SCULPTURES AND PAINTINGS: THEIR SIMULATED DESIGN, DEVELOPMENT AND APPLICATION TO INVESTIGATE THE CHOLA PERIOD MARITIME ACTIVITIES

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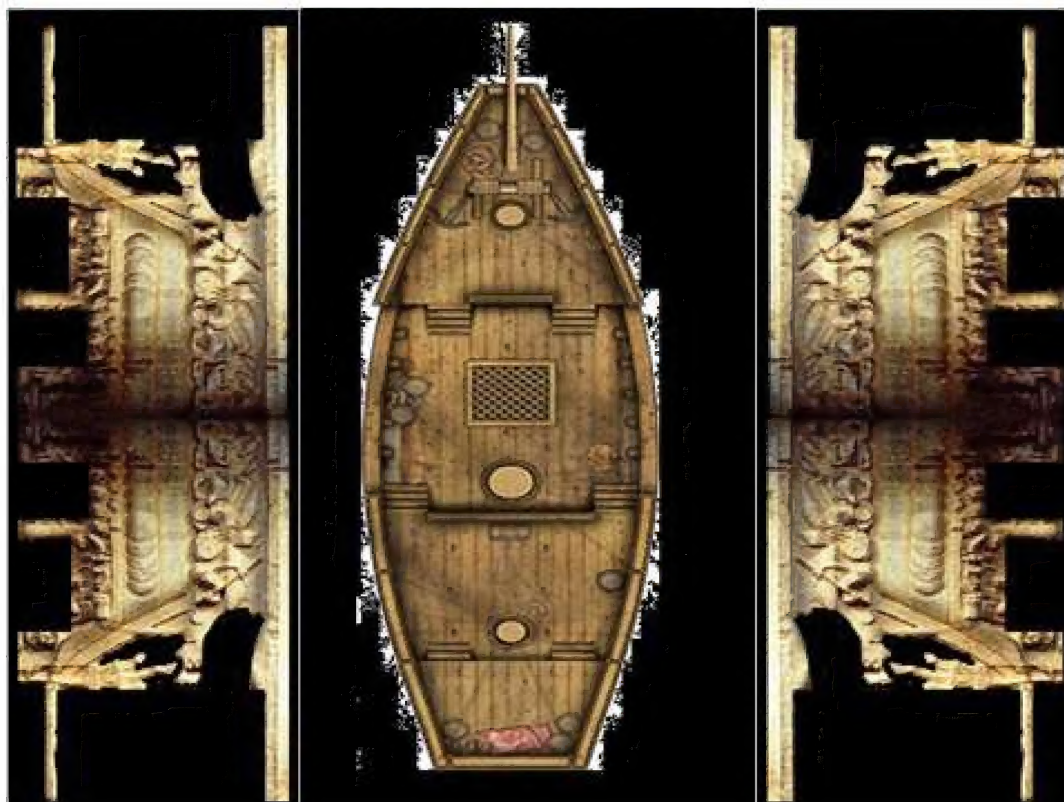
## Introduction

The maritime activities of the Indians and in particular, the Cholas cannot be doubted, just because, marine archaeologists, historians or serious researchers have not discovered, recovered or found any ship used by them. When they claim that they study history, "scientifically," such doubt could not have arisen, had they had dealt the issue scientifically with the concepts of "science and technology behind," or "cause and effect" of the existing evidences. The South East Asian (SEA), Bengal, Orissa, Andhra, Karnataka and other literary, inscriptional and archaeological sources prove the sojourn of the Cholas to these areas. From Indus Valley Civilization to Medieval periods, the internal and external navigational and maritime activities have been well established. The people movement of merchants and merchandise, priests and warriors and others vouchsafe the cross-cultural, interactive and reciprocatory activities among them. Under such circumstances, with the available Boat and Ship depicted in the Rock art, sculptures and paintings, scientific methods of reverse

engineering<sup>1</sup>, back engineering, their Simulated design, development and application to investigate the Chola period maritime activities is carried on in this paper.

## How a ship can be simulated and reconstructed?

About the reconstructed "Cholas ship" exhibited at the Tirunelveli museum, mention has been made in my earlier papers<sup>2</sup>. There have been attempts<sup>3</sup> to virtual reconstruction of ships using computer modeling with the available data combining nautical archaeology and computer visualization. The South Indian maritime trade with East African coastal countries during medieval period has been very interesting and revealing throwing light on Pallava, Colas and Kadamba maritime trade and shipping. The striking examples have been Shanga bonze lion, Brass tumbler found in Rhodesia, Limpopo-Kruger Park – sprouted vessel. Sean McGrail<sup>4</sup> shown that the Portuguese could have derived the ship design methods from South India, particularly from the people on the Coromandel coast, as the people from Kanyakumari to Puducherry have been using the same ancient





methods of ship-building with the methods like "building by eye", "art & craft", "by eye", "by arm" etc., that is, as they have established and practicing standards, they do or may not make measurements in cutting and sawing the wood, manufacturing parts and joining them together to build a boat or ship. Similarly with the depiction of ships in the sculptures and on the coins, the ships used by the Satavahanas, the Pallavas, the Kadambas, the Cholas, and others could be reconstructed. The data and information given in the Tamil works like Kappai Sattiram, Navar Sattiram etc., could be used for comparison. In computer programming<sup>5</sup>, it reconstructs to simulate the original or model to understand, how, it was made and used. A typical science of ship design could be watched in this video<sup>6</sup>. The Research on *Ship Design and Optimization Based on Simulation-Based Design* (SBD) can be equated with the "Experimental Archaeology<sup>7</sup>."

**Earlier attempts done by the scholars to reconstruct Chola ship:**

B. Arunachalam<sup>8</sup> with the help of Indian Navy undertook an expedition just like as Cholas did under the project, "*Simulation of Cholas Navigation Techniques*". He tried to build on the navigational practices, skills and wisdom that finally culminated in the Cholas naval expeditions to Malaya and Indonesia and cultural-cum-trade emissaries to China, based upon limited medieval documentation in the North Indian Ocean arena, and oral knowledge and living practices of the Coromandel Coast. The voyage also tested hand tools that were adopted by Rajendra Chola's convoy voyages in 1022 CE. Chola's voyages are also credited with concepts like that of parallel sailing (sailing parallel to the equator), which can only be practiced in the Indian and Pacific oceans. However, the expedition was aborted and they could not proceed, because of climatic and as well as technical reasons<sup>9</sup>. Because of ill health, he too did not join the abandoned voyage. Thus, his "package" was reduced to compilation of already available materials.

**Boat and ship depicted in rock paintings<sup>10</sup>**

Kizhvalai<sup>11</sup> rock paintings depict men standing on a boat, as they have been opened to nature, the details have not been clear and are dated to c.1000-500 BCE, and, Government of

India issued a special postal cover on 08-10-2011 under "Maritime Heritage of Tamilnadu" during SIPEX 2011 - Philately exhibition organized by SIPA - South India Philatelists' Association, Chennai, recognizing its importance. A noteworthy depiction of sea-going vessels has been reported from Chamardi near Bhavnagar in Gujarat, which is seen in the west coast of Saurashtra even today. The depiction reveals structural and technological features of small sea-vessels. Besides the main body of a boat (hull) and human figures as sailors, one could find rudder, masts, weathervanes, flags and anchors in the picture. These two examples are cited for illustrative purposes, though, many are there in the context. Thus, the knowledge of ancient Indians in boat and shipbuilding can be appreciated.

**Azhagankulam Ship graffiti is Indian**

Another evidence is from the excavations of Azhagankulam [Mandapam village, Ramanathapuram District], where, one of the potsherds contain a ship graffiti. As it was found with rouletted ware and Amphorae jar pieces with Tamil Brahmi letters assigned to first cent. BCE, it is considered as "Roman ship."<sup>12</sup> However, the masted ship with rowing rudder and other controls depicted point to Indian ship. To cite another example, the material evidence – the so-called Sri or Lakshmi, the ivory Indian statuette recovered from Pompeii. The scholars<sup>13</sup> vaguely note that "*....it might be dated somewhere between the end of the first century BC and the start of the first century AD*". However, the simple façade from where this was found has been dated to the Samnite era (3<sup>rd</sup>-2<sup>nd</sup> cent BC). And what about the artistic standards of the statuette? To quote<sup>14</sup>, "*On the whole, the statuette provides evidence of remarkable workmanship, for the graceful movements and the calm expression of her face*". In other words, during the period 300-200 BCE, the Romans were purchasing / importing ivory statues from India. Therefore, it cannot be categorically concluded that the ancient port Azgankulam was "Roman," as the Roman city Pompeii cannot be called as Indian city, just because, Lakshmi figurine was found there<sup>15</sup>. Thus, The ship depicted in the graffiti can be taken as Indian.



## The Pichili Trader vessel and Ajanta representation

Ivon A. Donnelly<sup>16</sup> has pointed out that the Pechili trader was probably the oldest type of ocean-going Chinese junk and they resembled the representations found in the Ajanta cave paintings in India and as well as the ones depicted in the sculptures of Borobuddur, proving the Buddhist link in the transfer of such technology from India to China. James Hornell too notes as follows, while he discusses about the usage of “eye” and goddess depicted on the bow of the ship with other decoration<sup>17</sup>: *“The pictures of a three-mast ship and of a Royal barge on the walls of the Ajanta caves (A. D circa 600) show that this custom was in use formerly-probably habitual. The Greeks, Romans and ancient Egyptians followed the same custom, and although it has died out in India save at this out-of-the-world- spot. It flourishes among the junks and samparans of China and Indo-China. The custom is not followed by the peoples of Malaysia – possibly because of Muhammedan influence”*. This clearly points to the fact that the Chinese must have derived such design from the Indians / the Pallavas / the Cholas. In the case of Malaysia, the sailors were converted to Islam and thus the “eye opening,” breaking of coconut, yearly festival etc., were stopped. The SEA nations have been at strategic location for the Chinese junks going to African and Arab countries to sell their goods to European countries. Similarly, for Indian ships going to China, they play crucial role. During first centuries, the Indians must have exercised total control over the SEA area and later during the medieval period the Chinese started competing with the Cholas. Much of the Cholas-Srivijaya-Chinese conflict could be analyzed in the context easily.

### The tradition of “ship-type” coins continued from Satavahanas disappeared during the Cholas!

The introduction of “ship-type coins” has been attributed to the Sathavahanas<sup>18</sup>, who were ruling the south during c.200 BCE onwards, just touching the northern boundaries of the Tamils of the Sangam period. However, such coins have also been issued by Salankayanas, Kurumbas and Pallavas. Incidentally, the depiction of two-mast ship appears to be a standard in the ancient Tamizhagam, as such depiction is found on the Alangulam pottery also. The Pallava coins also

depict both one-mast and two-mast ships and also single-mast boat with Nandi / bull symbol on the observe. Sir Walter Elliot<sup>19</sup> gives interesting description for the two-mast ship depicted in Pallava coin: *“Two-mast ship like the modern coasting vessel or d’honi, steered by means of oars from the stem”*. About this ship-type coins, he records that there were two and both were found missing and then, one recovered. In his words<sup>20</sup>, *“This is one of the two coins mentioned on p.36, supposed to have been lost. It was discovered in arranging the present series, but the other is still missing”* (1884). In another Pallava coin (numbered as 55 in plate II), he comments that observe has ‘a horse facing right, with a pellet in front’ and reverse ‘indistinct’. But, the reverse depict a two-decked ship, perhaps which he did not want to acknowledge, as it would be too modern to be imagined in the Pallava period! In fact, he calls them as “Kurumbas”. These coins were recovered from the coastal Labis and Merkayars in exchange for useful necessities. About the coins, he describes as follows<sup>21</sup>:

*“Those of native origin are small, irregularly rounded pieces of thin copper, bearing generally the device of a bull, with occasionally some letters in Cave-character on the observe; and on the reverse, a tree, ship, star, crab, fish etc. but their most remarkable characteristic is the elegance and delicacy of form with which the animals are designed, indicating a considerable advance of art; and in this respect contrasting favourably, but with the Andhra money on the one side, and with the Chola, and Pandyan currencies on the other”* (emphasis added).

That the Chola symbol was used proves that their presence was established with dominance and issued coins. Therefore, the Cholas, in spite of their maritime activities, they had not issued any “ship-type” coins or such coins not available / disappeared and such other exigencies are intriguing and logically does not fit in any argument or interpretation. It is evident that just like “Leiden grant copper plates,” they might have also been taken away by the European Companies.

**The Indian ships depicted in the European paintings confess that they were manufactured in India:**

The European paintings of ships and documents vouchsafe that 800 MTs were built in



Kochi around 1512 and they were used by them. Santa Catarina do Monte Sinai, was a higher-castled Portuguese carrack with 140 MTs, launched in 1520, was built at Cochin in 1512, and it was depicted in a painting attributed to Joachim Patinir. Incidentally, in 1524, Vasco da Gama came in this ship to India, in his third voyage. The documents preserved at the Ports of Madras, Bombay and Goa give interesting details about the ships built in Indian ports that were exported to European countries with cargo. The Narsapur peta shipping technology had been well documented, but, now there was no trace of it there<sup>22</sup>. Similarly, the European paintings depicting ships at Pulicat, Madras, Tranqubar, Nagapattinam and other coastal places prove the shipbuilding activities taken place, but, facts were suppressed by unknown reasons. Not only the paintings depict Indian ships, but also, carpenters and wood working experts working and using different tools to work with wood, planks etc. Thus, not that technology was forgotten or abandoned, but, the maritime activities were completely taken over by the Mughals and then the European Companies. Just like Narsapur, the evidences have been disappeared. John Lewis Ricardo<sup>23</sup> record about the high standards of Indian ships and their sea-fitness even for about 100 years.

*"Do not let it be said, "those Indian ships are built for their own coasting trade, and are unfit for long voyages." The very reverse is the fact, for, generally speaking, they are of a larger tonnage than the average tonnage of British ships. They are built of teak wood, and are the finest ships in the world. "I have seen", says the witness, "a teak ship that was 80 years old, going to sea, and perfectly seaworthy".*

Though, the British have recorded the excellent techniques of Indians, they have been suppressed from the Indians in history. Thus, when such excellent ship-building techniques were prevalent even during the British period, it is unimaginable that they were not existence 750-800 years before them.

*For further information as to the excellence of Indian ships and of Lascars as seamen, see appendix letter of Captain R. Cogan, J. N.*

Considering the importance, his letter is appended as APPENDIX - A. R. Cogan has analysed the quality, economy and easy repair and maintenance and longstanding of Indian ships as compared to the British-built ships<sup>24</sup>. The Indian ship-men, sailors, etc., whom they referred to as "Lascars", had been the best crew-men in the world. They have recorded them characteristically as follows<sup>25</sup>:

*The Late Mr. Soames, before the Committee of 1844, stated, "That going on the East India trade, he would rather have Lascars. In a warm climate you do not require a great number of them than of british seamen. Their great merit is in their orderly conduct; they are as quiet as lambs on board ship" - (619-21).*

George Windsor Earl<sup>26</sup>, who toured the Indian archipelago in 1832-33-34 comprising a tour of the island of Java - visits to Borneo, the Malay Peninsula, Siam and Singapore gives the following interesting details: *"The schooner, which was only fifty tons burthen, had been originally a Dutch gun-boat, purchased from the Batavian government, commander, an Englishman, who was the only European on board besides myself; the whole of the crew being natives of Eastern India"* (p.2 emphasis added). Here, two facts are brought out - not only the ship was built by them, but purchased from the Batavian government, but also the entire crew was Indian! They were far better than the British seamen, obedient and conduct orderly, *'they are as quiet as lamb on the board'*. This morality and values of Indians were only exploited by the foreigners and enslaved them by their own words.

### How the British gave a final death blow to Indian shipping

The Indian maps, astronomical charts, shipping, shipbuilding manuals, instruments etc., were taken away by the Arabs / Mohammedans and the Europeans have been recorded by many researchers<sup>27</sup>. The Portuguese got ships built from Indians<sup>28</sup>. The strategic occupation of Goa by them had been one of the important reasons, as it was the great port of navigating Kadambas. The arrival of Indian ships with Indian merchandise created a sensation in the port of London. Surat (1612), Madras (1639), Bombay (1668), Pondicherry (1674) and Calcutta (1698)



thus gradually overshadowed Goa, and took over as the main centers of Indo-European trade. Nevertheless, the Indian (and other Asian) shipbuilding industry continued to thrive, as ships built in the ports of the Indian Ocean often matched (or even exceeded) the European-built ships in finish and craftsmanship. The British started introducing several acts and rules to stop the Indian Shipping activities and foreign trade:

- The Merchant Seaman Act, 1728.
- The Merchant Seaman Act, 1835.
- The General Merchant Seamen Act, 1835.
- The Mercantile Marine Act, 1850.
- The Merchant Shipping Act, 1854-1894, etc.

The British gave a death blow to Indian shipbuilding by a notification issued by East India Company in the Calcutta Gazette (Supplementary) of 29<sup>th</sup> January 1789 which says "All persons whosoever (Magistrates of the District excepted) are prohibited from making use of, or constructing boats of the following denomination and dimensions after 1<sup>st</sup> March next:

- Luekhas 40 to 90 covids length 2 ½ to 4 covids breadth.
- Jelkias 30 to 70 covids length 3 ½ to 5 covids breadth.
- Paunehways of Chandpore carrying more than 10 cars.

According to Captain Iwata, founder member of the Association of Sumerian ships in Japan, Beypore<sup>29</sup> (an ancient port near Calicut / Kozhikode) had direct links with Mesopotamia and was probably a major stop in the maritime silk route. The typical features of ships built at Cochin and Maldives have ".....made entirely of wood, the planks are held together by wooden nails and coir yam with a special glue made of fruit and tree resins are used for additional bonding". Beypore is also famous for the construction of the Uru, the traditional Arabian trading vessel. In fact, even now, ships are built at Kozhikode / Calicut (Beypore and Mappad) exported to SEA countries, as they prefer the tradition ships of India.

## The incomplete details available in the Tamil works on shipbuilding

Now coming to the Tamil works on shipbuilding, the "Kappal Sathiram" (Science and technology of ships and shipbuilding<sup>30</sup>) contains 13 verses of "Silapa Sathiram" (Manual for carving sculptures). The qualities of wood / log, cross-section, pith etc., have been described with astrological implications. The details and measurements of keel, mast, sail, anchor etc., have been given. The auspicious date for launching of built ship has also been given. The verses have been mixed, taken from other works haphazardly and composed with a lot of mistakes<sup>31</sup>. As other details are missing, it is evident that the manuscripts available now have been incomplete. Another work, "Navay Sathiram" (A Manual for boat and ship manufacture)<sup>32</sup> has also been similar to that of Kappal Sathiram. Yet another work has been "Kappal kovai" (A Compendium on ships)<sup>33</sup> that gives a lot of details about the maritime activities glorifying the Cholas, particularly, Rajendra Chola. Moreover, there had been many tools, implements and machines were evidently used but they are not available. When Suryadeva Yajvan could sit at Gangaikonda Cholapuram, write a commentary on "Aryabhatiyam," and it is available, it is surprising that only copies and incomplete Tamil manuscripts are available. Yet, as the ships are still manufactured at Baypore, Mappad, Caddalore and other places, the science and technology behind cannot be denied.

## The transition taken place from the Moghuls to the British and the Impact on Indian shipbuilding

The large sized and high tonnage ships were built only in India even during the British period as pointed out above. Master shipbuilder, Jamshetji was buiding and supplying to them<sup>34</sup>. There have been manuals and handbooks of wooden boat and ship building that give step by step building from the log stage to sail stage. The Arabs, and then the European Companies had taken away all the Indian books on shipbuilding except few available in Tamil, as mentioned above. The description of the woods and logs, their internal structures and grains, veneer orientation, selection etc., have been meticulously explained, but couched with astrological implications. However, when the



Mohammedan and the European Companies entered, such ethics had gone. While the Arabs working with the Indian kings got converted and the European Companies absorbed Laskars and other shipbuilding workers, with the banning of high tonnage ships, the Indian shipping died a natural death<sup>35</sup>. As the parts of wooden ships were used, reused for repair and reconstruction, evidently, the old ships were made to disappear then and there. This is the answer for the disappearance of the Cholas ships or the ships used by the Cholas.

### **The East Indiaman – the ships that were built in India and used by the Europeans**

The Indian ships had been so famous by all means and they were characteristically known and called as “East Indiaman.” East Indiaman was a general name for any sailing ship mostly built in India, operating under charter or license to any of the East India Companies of the major European trading powers of the 17<sup>th</sup> through the 19<sup>th</sup> centuries. The term refers to vessels belonging to the Austrian, Danish, Dutch (Oostindievaarder), English, French, Portuguese, or Swedish (ostindiefarare) East India companies. According to some sources, the expression, “tea clippers” was used to such ships chartered by the British East India. Historian Fernand Braudel, recorded that some of the finest and largest Indiamen of the late 18<sup>th</sup> and early 19<sup>th</sup> centuries were built in India, making use of Indian shipbuilding techniques and crewed by Indians, their hulls of Indian teak being especially suitable for local waters. The biggest vessels of the Bombay Marine were built in India, for cost effectiveness. With the mechanization of the ships, the monopoly of the British East India Company got reduced and during the late 1830s a smaller, faster ship known as a Blackwall Frigate was built. The last of the East Indiamen was reputed to be the Java (1813–1939) that became a coal hulk, then was broken up. Thus, East Indiaman proves the continued shipbuilding technology of the Indians till 19<sup>th</sup> century from medieval period.

### **Simulation, sculptural model and traditional shipbuilding**

Simulation of boat/ship models is possible with CFD [Computational Fluid Dynamics] analysis. For traditional snake boats of Kerala, such attempt has been made<sup>36</sup>. For the traditional

Chiloean boats also, digital design techniques applied to reconstruct<sup>37</sup>. As the diagrams, drawings and paintings of the Indian ships built are available depicting them since medieval period, they can be taken as virtual model matching with the available examples of the Tamilnadu examples of Tirukkurungudi and Tirupputal Mardhur. As the pattern has been similar and same to the other ships built in India, these are taken as equivalent, though full view of the ships are not available. Then, technical details are obtained to investigate its seaworthiness and navigational capabilities. Because of technicalities involved, only few figures with brief explanation are given. They are compared with the literature Kappal Saththiram, Navai Saththiram, Kappal kovai etc. the sculpture model is converted into wooden model with assumed dimensions based on books that give details<sup>38</sup>. The manuals give details of shipbuilding from wood to sailing of the ship built<sup>39</sup>. Incidentally, such manuals have been published in the late 18<sup>th</sup> and early 20<sup>th</sup> centuries<sup>40</sup>. Incidentally, they resemble Indian works, but devoid of Indian method of astrology etc. As ships are still manufactured in Caddalore, Mappad and Baypore, such assumed dimensions are manipulated to suit the simulated conditions. Thus, it is proven that the Cholas had used ships for their oversea expeditions, as amply proven by the simulated ship design correlating, corroborating and corresponding with the literary, painting and sculptural evidences.

### **How the simulation helps in shipbuilding analysis**

Geometry, 2D to 3D, computer aided design, simulation program software, virtual lab and final designing and analysis. High Imagination, Isometric and orthographic projections, software developing and application skill are required:

1. Geometry is used in computers helping to conceive and visually represent complex spatial architectural environments.
2. Computer aided design (CAD) software produces model and visualizes any imaginable geometrical shape, which opens up new venues for experimentation with shapes that are different from the Cartesian geometry of straight lines.



3. 3D modeling software is not only helping to conceive these new complex forms, but is also assisting in the entire manufacturing process.
4. Thus, the 2-D sculptural design is converted into 3-D for the benefit of understanding and further working.
5. Simulation process is nothing but imitation, replication and recreation process and in shipbuilding, it is accomplished, when it is put on waters.
6. Sophisticated processes have been involved using 3D, CAD and other software. Here, an artificial sea and oceanic conditions are created with waves, wind flow, rains and even cyclonic effects.
7. The model is slowly assumed, figurized and finalized slowly achieving the optimum level, tested under the above simulated conditions.
8. In such trial and error process, with software, just-original condition is approached and attained and the dimensions are also obtained.
9. Softwares are used for computing hydrodynamic motions and loads on vessel hulls for strength and fatigue analysis. Software are also used to determine vessel response to wave environmental conditions.
10. Such capabilities are required to study critical operational details such as cargo swaying as it is lifted, relative movement of a moored vessel and interaction of adjacent ships as well as the ability of the ship to hold a given position in heavy seas.
1. The Indian knowledge of science and technology of the shipbuilding has been historical fact, so also that of the Cholas and other medieval South Indian kingdoms.
2. The Satavahana, Pallava tradition continued with the Cholas, Andhras, Kalings and Palas.
3. The Cholas, Andhras, Kalingas and Palas evidently helped each other in their maritime activities. They could be linked and united with the trade guilds that were operating for many centuries.
4. The Tirukkurungudi and Tiruppudai Mardhur ship models are capable of handling such huge tonnage of cargo.
5. That is why the Arabs could bring hundreds of horses to South India. In the same way, elephants could have loaded in the ships. Rajendra could have brought elephants from Siam and such events were depicted in the literature and inscriptions.
6. The East Indiaman proves the continued shipbuilding technology of the Indians till 19<sup>th</sup> century from medieval period.
7. The critical investigation on source materials and material evidences of Indian shipping, shipping technology and technical tools and manuals used, the work force used etc., prove that there have been explicit gaps that have not been studied so far.
8. Though, some scholars<sup>41</sup> have gone to Lisbon (Portugal), London, Paris, Copenhagen (Denmark), Amsterdam (Holland / Netherland) and other archives to research into Indian maritime activities, they have not been enough informative on these details.

## Conclusion

From the above analysis, whether the inscriptional claims of the Cholas conquering many distant countries is possible or not is assessed with the simulated model. Whether they actually had naval fleet to sojourn three, ships loaded with elephants, bring the gift of the golden chariot by the Cambodian King or not also evaluated and confirmed with the data analysis.

9. With the multi disciplinary studies like this, more details could be obtained to solve the historical and archaeological riddles.
10. It is right time that the students of history, archaeology and related disciplines have one paper on "Science and Technology useful to Historical and Historiographical Studies," so that they scientifically deal with the subject matter.



## End Notes

1. Reverse engineering, also called back engineering, is the process by which a man-made object is deconstructed to reveal its designs, architecture, or to extract knowledge from the object; similar to scientific research, the only difference being that scientific research is about a natural phenomenon. Reverse engineering is applicable in the fields of mechanical engineering, electronic engineering, software engineering, chemical engineering, and systems biology.
2. K. V. Ramakrishna Rao, *A Critical Study of the Shipping Technology of Cholas*, A paper presented during the Teradic National Conference on Bharatiya Heritage held at S. D. M. College, Ujire-Dharmasthala, fro May 13<sup>th</sup> to 16<sup>th</sup>, 2008. To appear in the proceedings.  
..... *The Chola-Chinese Connection*, a paper presented during the 29<sup>th</sup> session of South Indian History Congress held at Manonmaniam Sundaranar University, Tirunelveli from Jan.30<sup>th</sup> to Feb.1, 2009, PSIH, pp.254-257.  
..... *The Shipping Technology of Cholas*, a paper presented during the 27<sup>th</sup> session of South Indian History Congress held at Rajapalayam from Feb. 2 4, 2007, PSIH, Rajapalayam, 2007, pp.326-345.
3. Audrey Elizabeth Wells, *Virtual Reconstruction of a Seventeenth-century Portuguese Nau*, a thesis submitted to the Texas A & M University, USA, 2008.
4. Sean Macgrail, *Portuguese-derived ship design methods in southern India?*, Proceedings of International symposium on Archaeology of medieval and modern ships of Iberian-Atlantic tradition, pp.119-129. Also see at: <http://carlosmontalvaob.blogspot.com/> and Pepper-wreck project etc.
5. Reverse engineering, in computer programming, is a technique used to analyze software in order to identify and understand the parts it is composed of. The usual reasons for reverse engineering a piece of software are to recreate the program, to build something similar to it, to exploit its weaknesses or strengthen its defenses.
6. The Science of Ship Design, <http://youtube.com/watch?v=T7bY1QjKt70>: There have been many videos tutoring the techniques involved, Now, Indian maritime Universities offer such courses.
7. Experimental archaeology (also called experiment archaeology and experiential archaeology) is a field of study which attempts to generate and test archaeological hypotheses, usually by replicating or approximating the feasibility of ancient cultures performing various tasks or feats.
8. B. Arunachalam (Ed), Essays in Maritime Studies, Vol. 1 & 2, Maritime History Society, Mumbai (1999-2002).  
..... *Heritage of Indian Sea-Navigation*, MHS, Mumbai, 2002.  
..... *Cholas Navigation Package*, MHS Mumbai.  
G. Victor Rajamanickam, *Traditional Indian Ship Building-Memories, History, Technology*, 2004.
9. The Maritime History Society (MHS) sailing team consisted of Cdr GVK Unnithan (Retd) along with Vivek Ganpule of the Tata Institute of Fundamental Research (TIFR) and Umesh Solapurkar of the Bhabha Atomic Research Centre (BARC) with Arunachalam and Cdr Mohan Narayan providing for ground monitoring. The ship was under Cdr Patankar's command. The voyage also tested hand tools that were adopted by Rajendra Chola's convoy voyages in 1022 AD. Chola's voyages are also credited with concepts like that of parallel sailing (sailing parallel to the equator), which can only be practised in the Indian and Pacific oceans. "It's the quest for truth that leads to these kinds of expeditions and voyages because even with all the knowledge that we have, there are big blanks in history," said Admiral (Retd) J G Nadkarni of the Maritime History Society and also former Chief of the Indian Navy. During almost half the duration of the voyage, the skies were overcast, making it extremely difficult for the navigators to follow paths as planned. Also, owing to an extended cyclonic season that extended to March, the leg of the journey from Nagapattinam to Vishakhapatnam had to be abandoned. Arunachalam, choosing to be modest, said the simulation was only a partial success owing to bad weather conditions. To further explore the great heights of a part of our maritime history, another expedition of a similar nature is required, he said. Thursday, April 17, 2008 at 0343 hrs IST.
10. K. V. Ramakrishna Rao, *Boat-ship depicted in rock-art, stone art and paintings of South India*, in "Indian paintings and Arts through Ages", edited by J. Soundarajan, University of Madras, Pranesh Publishers, Chennai, 2018, pp.171-178.
11. Kilvalai or Kizhvalai, is a hamlet in Tirukkoyilur (Tamil: கிழக்கோயிலூர்) taluk in Villuppuram district, Tamilnadu.
12. T. S. Sridhar, *An ancient Roman Port City of Tamilnadu*, Dept of archaeology, Govt. Of Tamilnadu, 2005, p.40
13. A. Maiuri, *Statuetta eburnea di arte indiana a Pompei*, Le Arti, Vol.I, 1939, pp.11-115. J. PH. Vogel, *Note on an Ivory Statuette from Pompeii*, Annual Bibliography of Indian Archaeology, Vol.XIII, 1940, pp.1-5.
14. R. M. Cimino and F. Scialpi, *India and Italy*, Is.M.E.O, Rome, 1974, pp.28-29.
15. The Pompeii Lakshmi is an Ivory statuette that was discovered in the ruins of Pompeii, which was destroyed in the eruption of Mount Vesuvius 79 CE. She was found by Amedeo Maiuri an Italian scholar in 1938. The statuette has been dated to the first-century CE.
16. Ivon A. Donnelly, *Chinese Junks and other native craft*, Earnshaw books, Hong Kong, 2008 (Reprint of 1924 edition), p.32.
17. James Hornell, *The Origin and Ethnological Significance of Indian Boat Design*, pp.42-43.
18. I. K. Sarma, *Coinage of the Sathavahana Empire*, Agam Kala Prakashan, New Delhi, p.227.
19. Sir Walter Elliot, *Coins of Southern India*, Prithvi Prakashan, Varanasi, 1970, p.152.
20. Ibid, p.152B.
21. Ibid, p.35.
22. Sanjay Subrahmanyam, "A Note on Narsapur Peta: A 'Syncretic' Shipbuilding Centre in South India, 1570-1700," *Journal of the Economic and Social History of the Orient*, 31 (1988), pp. 305- 11.



23. John Lewis Ricardo, The Anatomy of the Navigation Laws Charles Gilpin, 5, Bishops gate Street, London, 1847, p.123.
24. John Lewis Ricardo, The Anatomy of the Navigation Laws Charles Gilpin, 5, Bishopsgate Street, London, 1847, pp.331-333.
25. Ibid, p.123.
26. George Windsor Earl, The Eastern Seas or Voyages and Adventures in the Indian archipelago in 1832-33-34 comprising a tour of the island of Java - visits to Borneo, the Malay Peninsula, Siam & c. also an account of the present State of Singapore with the observations on the commercial resources of the Archipelago, Wm H. Allen and co, Leandral Street, London, 1837.
27. K. V. Ramakrishna Rao, The Shipping Technology of Coles, PSIH, Rajapalayam, 2007, p.342.
28. However, the kept silence of the procurement of Indian ships. Even the websites say that the ships were Indian Portuguese ships etc.
29. Located at the mouth of the Chaliyar river, Baypore, one of the prominent ports and fishing harbours of ancient Kerala was and important trade and maritime centre. Ancient Beypore was much sought after by merchants from Western Asia, for its shipbuilding industry and the boat-building yard here is famous for the construction of the Uru, the traditional Arabian trading vessel.
30. T. Chandrasekharan (Gen.Ed.), Kappal Sattiram, Madras Government Oriental Series, Government Oriental Manuscripts Library, Madras, 1950. Critically edited with introduction by T. P. Palaniyappa Pillai.
31. Nigama Sigamani, Jothida Graha Cithamani and other astrological works are implied and the verses from them copied verbatim. All these show that the "Kappal Sathiram" written at Tranquebar should be a fake one, just to fool Indian fresearchers and the original texts could have been taken away by the Dutch people.
32. S. Soundarapandian, Navai Sattiram, Madras Government Oriental Series, Government Oriental Manuscripts Library, Madras, 1995.
33. S. Srivivasa Iyer (Ed.), Kapparkovai, Mahamahopadhyaya V. Swaminatha Iyer Library, Madras, 1958, pp.xxi.
34. William Taylor Money, Observations on the Expediency of Shipbuilding at Bombay for the Service of His Majesty and of the East India Company, Longman, London, 1811.
35. There were many reasons attributed to why India's maritime trade and culture declined. One possible reason was the tension between the Brahmins and the Buddhists. The sea traders patronised Buddhism and the Brahmins patronised the feudal land owners - the Kshatriyas who controlled the 'kshetra' or land. In every culture there has been tension between the landowning rich and the trading rich. The kala pani belief spread among the Hindus and consequently the maritime trade and amalgamation of cultures started to decline except certain communities in Kerala and Gujarat that insisted on travelling, converted to Islam and forged marital relations with Arabs. Hinduism failed to flourish as Hindu priesthood was based on bloodline and castes, and since people could not travel across the sea or take their brides, across the sea, the Hindu tradition gradually waned. The decline in the maritime culture was the beginning of the era where our economic growth and cultural richness was overtaken by the European powers and subsequently we were subjugated by the British for close to two centuries. This period was very crucial, when we missed the Industrial revolution and the modern era of steel ships never took-off in the Indian subcontinent. Cdr (Dr) Arnab Das (Retd) and Ms Tiya Chatterji, Beneath the Blue SeaGull, May 2019 - July 2019, pp.33-34.
36. B. Venkata Subbaiah, Santosh.G. Thampi, V. Mustafa, Modelling and CFD Analysis of Traditional Snake Boats of Kerala, Aquatic Procedia, Volume 4, 2015, pp. 481-491.
37. Dujovne, David Butelmann, and Claudio Labarca Montoya. Digital design and manufacture based on Chilean boats, International Journal of Architectural Computing, Issue.3, Volume.6, 2008, pp. 317-333.
38. George Holmes, Ancient and Modern ships, Part-I, wooden sailing ships, Her Majesty Press, ondon, 1900.
39. H. Cole Estep, How wooden ships were built, The Penton Publishing Co, Chicago, 1918.
40. Richard Von Gaasbeek, A Practical Course in wooden boat and Shipbuilding, Frederick Drske & Co., Chicago, 1918.
41. K. M. Mathews, Jayasheela Stephen, Jayaraj, Sanjay Subramanian to cite a few. Had they wanted, perhaps, they could have given more details about the transfer of shipping technology taken place with al charts, manuals etc. C. K. Raju pointed out some details.